BUILDING INFORMATION MODELING (BIM) OF CULTURAL HERITAGE. CASE STUDY: 28 DRAGOMAN ST, VARNA, BULGARIA

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Abstract: The publication presents the efforts of the team of the R&D SME Architectural Spies EOOD of creating models of the cultural heritage (CH) building at 28 Dragoman St and 11 Bdin St, Varna, Bulgaria. The team vectorized the old paper plans from 1912, did aerial and terrestrial photos and movies, completed the data acquisition from 2D images to a 3D model, testing 3 types of software for photogrammetry, and finalized the building information model (BIM). The BIM is a base for creating the building energy model (BEM) and applications for virtual reality (VR) and augmented reality (AR) of the same building. The work is included as a virtual demonstration site in the H2020 project BIM-SPEED (Harmonized Building Information Speedway for Energy-Efficient Renovation).

Keywords: building information model, BIM, digitization, digitalization, photogrammetry, data acquisition, vectorization, cultural heritage, CH

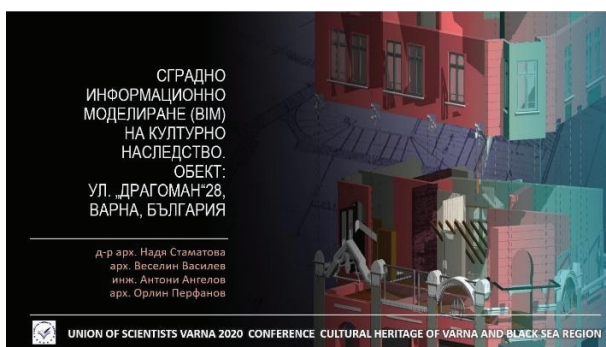*Fig. 1. English title slide of the presentation at the conference on 27 September 2020*

Fig. 2. Bulgarian title slide of the presentation at the conference on 27 September 2020

The cultural heritage building at the corner of the Dragoman and Bdin streets in the center of the city of Varna is one of the two Bulgarian demo sites (Fig. 3, 4), included in the H2020 project

BIM-SPEED (Harmonized Building Information Speedway for Energy-Efficient Renovation) (8) for extended reality (XR) (augmented reality—AR, augmented virtuality—AV, and virtual reality—VR) demonstrations.

Fig. 3. Page of the demo sites—cultural heritage buildings in the BIM-SPEED Internet site (8)
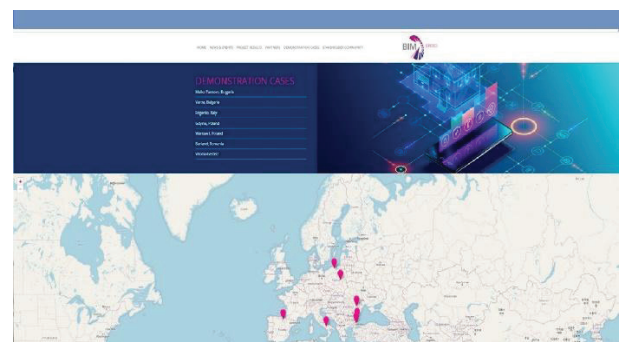

Fig. 4. Map of the BIM-SPEED demo sites, incl. both Bulgarian demo sites (8)

The building was designed in 1912 by the architect-engineer Joseph Hadzhistoyanov for the wholesaler Vasil Kojuharov (6). The original project documentation from 1912 (Fig. 5, Fig. 6), archived in Varna Municipality was scanned and vectorized by two types of software: the function Trace Bitmap of Corel Draw (Fig.7), and Vector Magic (Fig.8).
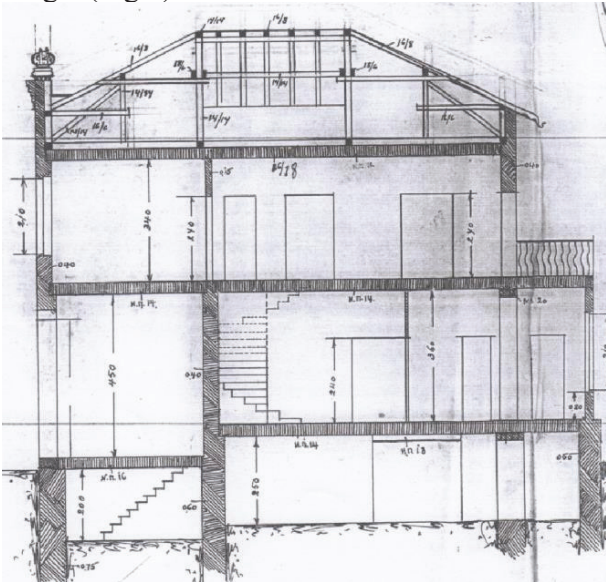

Fig. 5. Section—scanned copy from the original project from 1912
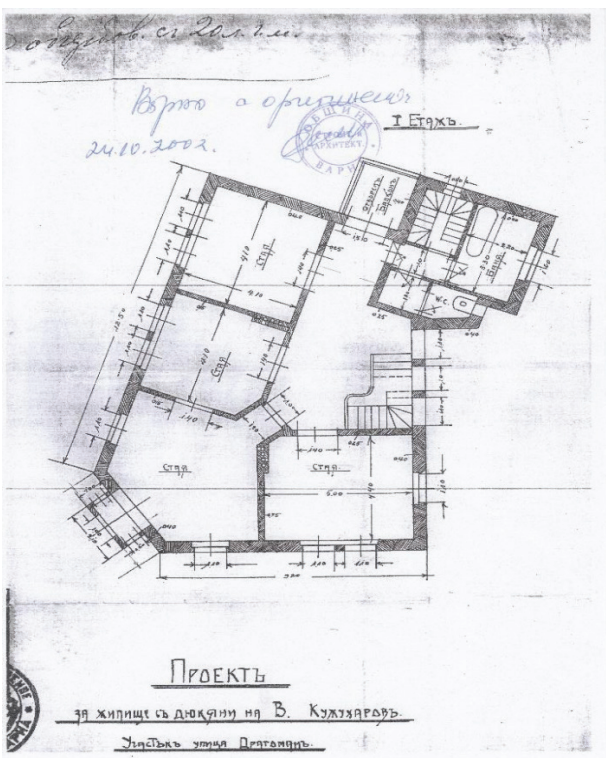

Fig. 7. Vectorization of the vertical section by Corel Draw software

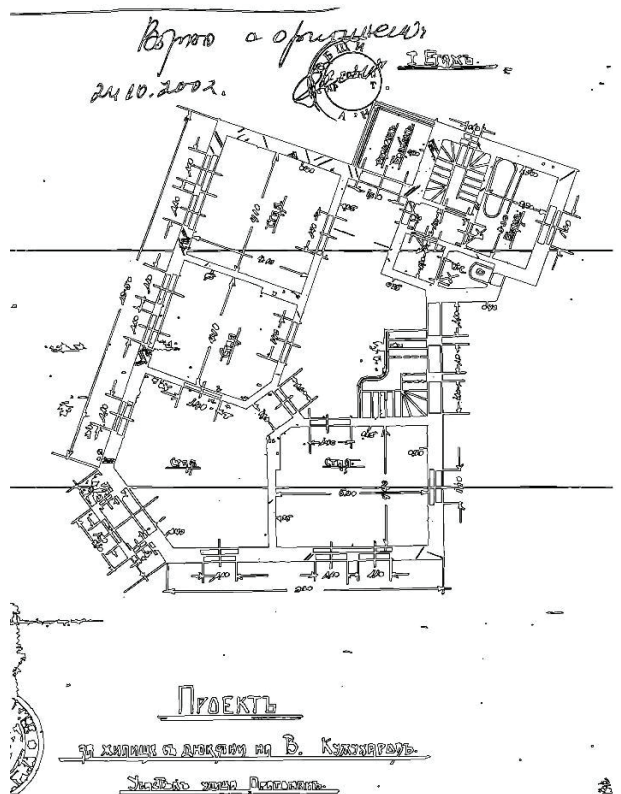*Fig. 6. Plan—scanned copy from the original project from 1912*

Fig. 8. Vectorization of the plan by Vector Magic software

Fig. 9. Terrestrial photo from a person's point of view

Fig. 10. Terrestrial photos with telescopic device

Fig. 11. Aerial photo by drone

The digitization and vectorization of all existing drawings is an important part of the process of creation of as-built BIM asset. The process of creation of BIM assets consists of two stages: collecting data and creating the model with implemented meta data.

The collected data were:
- copies of the original old blueprints from 1912;
- documentation for further renovation and amendments through the years;
- controlling measures with measuring tape and a laser measuring device (Bosch);
- terrestrial photos of the interior and exterior;
- terrestrial videos of the interior and exterior;
- aerial photos of the exterior;
- aerial videos of the exterior.

The terrestrial photos and the videos were produced by Sony CyberShot DSC-W220 digital camera with 12.1 megapixels, several smartphones used at low levels and at high levels with simple selfie sticks and with a produced by our team telescopic device (Fig.10) for terrestrial surveys with a height of 4 m. The aerial photos and videos were done by a drone (Fig.11). The drone of Architectural Spies is Xiaomi Mi Drone 4K with a camera 4K video; 12.4MP photos, image resolution: 4000 x 3000, video: 3840x2160p 30 fps; 2560x1440p 30 fps; 1920x1080p 100/60/30 fps, FPV (real-time video) Full HD directly to smartphone or tablet, 360 ° flip.

Fig. 12. Interior photos and Bosch measuring device

Some of the problems producing 3D models by photogrammetry were analyzed in two of our publications in 2018 (3) and 2019 (1), The software that we used in 2019 for this case study was ReCap (16) and Zephyr (13, 14). Since 2020 we have also added Meshroom (9, 10).
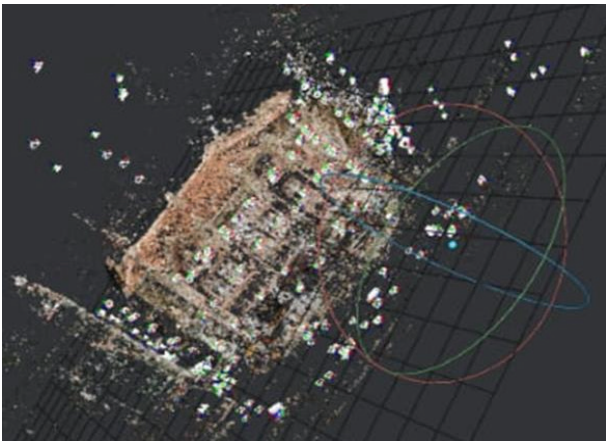

Fig. 13. Point cloud by photogrammetry, a process of work with Meshroom (9, 10)

Fig. 14. Photogrammetric model produced by software ReCap (16) opened in Blender (11, 12)

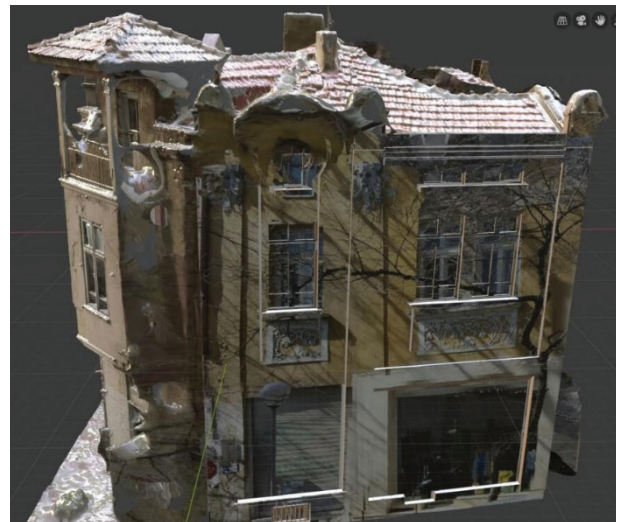*Fig. 15. Photogrammetric model of the interior produced by Meshroom (9,10)*

Fig. 16. Pseudo-photogrammetry compilated in Blender (11,12)

We had a big problem with the façade, facing Bdin street. The same problem was reported also by our partner—the Technical University of Berlin, the coordinator of the BIM- SPEED project for their demonstration site in Germany. It concerned the trees, which were making a curtain by branches and leaves. We were waiting for the winter season to take new pictures, trying to isolate in Photoshop the images of the tree branches but this method did not bring a satisfactory result. Later, at beginning of the summer, we took new photos, especially during the day when some of the tree branches were removed for assembling the scaffolder for the façade renovation. This was the last opportunity before starting the façade renovation. Despite our efforts, these images did not give a good result. In the end, we solved the problem by pseudo- photogrammetry, designed a wall in Blender, and upholstered its surface with true photos (Fig.16).

The photogrammetric models of the interiors were tested by the 3 types of software: ReCap, Zephyr, and Meshroom (Fig. 15).

3D models of some of the more complicated decorative details, using 3D mesh and a textured model, were done. Especially the masks (the so-called in the architecture "mascarons") on the pilasters were isolated, cleaned, and polished, preparing them for importing to Revit. 3D Max (10) was used intermediating between the two modeling environments Blender and Revit.

after in-depth research of the walls, floors, roof, and basement with their layers. This step was an essential point of the study. We created a federated model of the building: architectural and structural walls, water and plumbing installation, electrical installation. This helped to understand more in-depth the problem points and weak spots of the building construction, insulation, thermal bridges. The model included the chronology of the changes of the building interior and exterior, incl. the elements, which were not visible (for example, the detailed floor construction with 3 layers of wood beams and steel girder, etc.).

Fig. 17. A 3D model of a mascaron isolated in the modeling environment of Blender (11)

The building information model (BIM) of the demonstration's building was produced by the software Revit. Despite the fact that we had the photogrammetric 3D model, we needed more in-depth details of the building. More information of the categories for building components was imported and realistic structure and substructure were created.
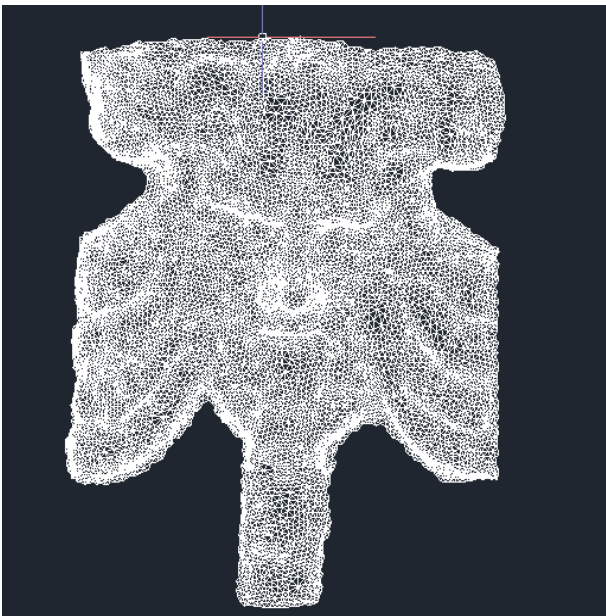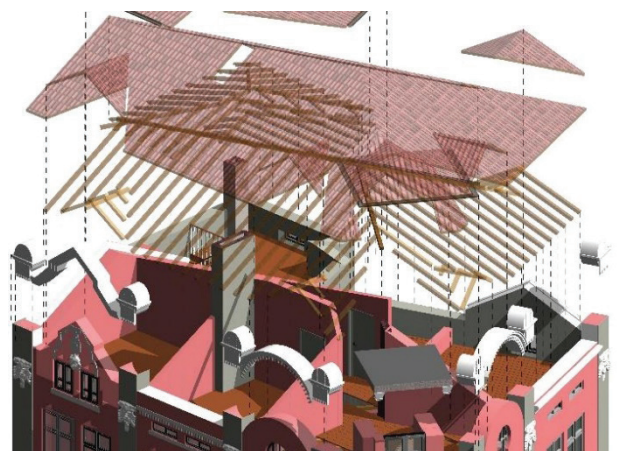

Fig. 18. A 3D model of a mascaron edited as facet surface, prepared for import to Revit.

Most of the building structural elements were hidden and could be investigated only

Fig. 19. Vertical section through the detailed floor structure with 3 layers of wooden beams and a steel girder

Fig. 20. Detailed study and analysis of the existing roof construction

Fig. 21. Horizontal displacement study of walls, wall construction, and layers, pilasters, ornamented decoration, mascarons, cornices, windows

Fig. 23. BIM of the building before the renovation (as-built model)

Fig. 22. Vertical displacement study of walls, wall construction, floor structure and layers, pilasters, ornamented decoration, mascarons, cornices.

Fig. 24. BIM project for renovation

Creating a BIM model is a cutting-edge technology to allow export of the model in various 2D and 3D graphical formats as DWG, IFC, DXF, DGN, ACIS (SAT) preserving geometry and data asset. All the data can be easily and safely stored and accessed on online platforms or clouds to meet the common digitization standards.

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